XVI International Symposium on Very High Energy Cosmic Ray Interactions (ISVHECRI 2010)

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Fermilab

Book of abstracts

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“Some consequences of the results of cosmic ray investigations above the knee for LHC experiments ”

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During last tens years many unusual results which are very difficult to explain in frames of existing theories and models were obtained in cosmic ray investigations. But it is possible to explain all these results if to suppose that some new state of matter with effective mass about TeV and with large orbital momentum appears. This new state of matter can be, for example, quark-gluon plasma, some specific resonance state, principally new short-lived particle and even Higgs boson with very large mass (about TeV).
In this talk, explanations of various unusual cosmic ray events in frame of this hypothesis are given and consequences for accelerator physics experiments (first of all, at LHC) are considered.

Balloon and Satellite Experiments / 3

Balloon-borne gamma-ray telescope with nuclear emulsion

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We are planning to observe cosmic gamma-ray in the energy range 10MeV to 100GeV by balloon-borne gamma-ray telescope with nuclear emulsion. Nuclear emulsion is a precise tracker. By detecting starting point of electron pair, gamma-ray direction can be determined precisely (1.4mrad@1-2GeV). This is much better than Fermi Gamma-ray Space Telescope launched June 2008. Now we are developing the gamma-ray telescope with nuclear emulsion and are planning to observe by balloon flight. Overview and status of our telescope is talked in this presentation.

Extensive air shower experiments / 5

Cosmic ray data and their interpretation: the Tibet hybrid EAS experiment -- Primary energy spectra of Cosmic Rays at the knee and tests of hadronic interaction models --

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The Tibet hybrid air shower experiment is composed by an air-shower core
detector array and the air-shower array (and a large muon detector from October, 2010), that has been operated at Yangbajing (4300 m above sea level) in Tibet, China, since 1996. This multi-detector system is used for the search for high energy celestial gamma-ray and cosmic ray sources, and for the study of the chemical composition as well as the energy spectra of nuclear-components in the knee region. Both are aimed to investigate the origin of high energy cosmic rays through different approaches. In this talk, based on the chemical composition and the energy spectra of some individual nuclear components around the knee, we would like to discuss the sharp knee observed by our experiment and its relation with the contribution of possibly existing nearby source(s). We would also discuss the check of currently used hadronic interaction models by using new Tibet hybrid experimental data. We also plan to build a ground based large and complexγ/CR observatory at high altitude (4300m a.s.l.) within 10 years.

Sensitivity of Monte Carlo models to data / 7

New Development in EPOS 2

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Since 2006, EPOS hadronic interaction model is being used for very high energy cosmic ray analysis. Designed for minimum bias particle physics and used to have a precise description of SPS and RHIC heavy ion collisions, EPOS brought more detailed description of hadronic interactions in air shower development. Thanks to this model it was possible to understand why there was less muons in air shower simulations than observed in real data. With the start of the LHC era, a better description of hard processes and collective effects is needed to understand deeply the incoming data. I will describe the basic physics in EPOS and the new developments and constraints which are taken into account in EPOS 2, and their consequences on air shower development.

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On the electron/positron excesses and the knee of cosmic ray spectra

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Based on the cosmic rays acceleration in the young supernova remnant like environment, electron and positron pair production through the interactions between high energy cosmic rays and radiation background photons is studied. It is found that both the electron/positron excesses and the knee structure of the cosmic ray spectra can be explained with one set of the source parameters.

Poster Session I - Board 6 / 10

Search Sources of Cosmic Rays Ultrahigh Energy

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The arrival directions of ultrahigh energy extensive air showers (EAS) by Yakutsk, AGASA and P. Auger data are considered. For the first time, the arrival directions of extensive air showers of ultrahigh energy, registered by Yakutsk EAS array more carefully are considered. It is found that the arrival directions of EAS Yakutsk data are correlated with pulsars from side Input of Local Arm Galaxy Orion. Also it is found that from this side the arrival directions of EAS by data AGASA are correlated with pulsars, the arrival directions of EAS by data P.Auger are correlated with pulsars from Outside of Local Arm Orion. It is shown the majority these pulsars have a short period of rotate around of their axes. The problem of cosmic ray origin is discussed.

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Behaviour of the EAS age parameter in the knee energy region

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We review the different definitions of the age parameter used in the lateral and longitudinal electron distributions. In order to remove ambiguities in the interpretation of the experimental data, we have compared simulations with CORSIKA carried simultaneously with the options NKG and EGS.
The effect of the positron annihilation cross section missing in the NKG approach is pointed out for small and inclined EAS, near the axis ; the consequences of the electrons coming from muon decay at large distances from axis are also underlined.
Distinguishing the longitudinal, lateral and local age parameters, correspondances and conversions between the 3 categories are inferred from the simulations.
Finally, the age parameter derived by fitting the lateral profile of the electron distribution, is confirmed as a good indicator of the primary composition and the hadronicity of the cascade as far as some conditions are fullfilled concerning bands of istances to the axis and zenith angle, dependant slightly on the primary energy (examples in the interpretation from Kascade and Akeno data).

Sensitivity of Monte Carlo models to data / 12

Consequences of the LHC results in the interpretation of gama ray families and giant EAS data

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Present results of the LHC (up to 26 PeV in the Lab. system) are a very small lever arm for the extrapolation of models up to 100 EeV. However, the measurements of CMS exhibit a central pseudo rapidity density larger than the prediction of the different models. Introducing on this basis new guidelines, with larger multiplicities in the models inserted in thesimulation, we examine the consequences for gamma ray families and very large EAS.
A special attention is given to the coplanar emission observed near 10 PeV : the case of large Pt's generated during the fragmentation of relativistic strings involving valence diquarks (partonic model+Schwinger mechanism)is explored as a possible source of alignments at this energy.
At larger energies , the effects of those circumstances in the interaction fragmentation region are investigated, together with large multiplicities, as the possible origin of the small penetration power of proton initiated showers in the atmosphere. Associated statisticalbias generated by a sharp knee or ankle in the primary spectrum are also considered.

Experiments above the Ankle / 13

A Relation Between Charged Particles and Muons With Threshold Energy 1 GeV in Extensive Air Showers Registered at the Yakutsk EAS Array

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For a long time the three main components of extensive air showers have been measured at the Yakutsk array: the whole charged component, muons with e_{th} \ge 1 GeV and Cherenkov light. Using these data we reconstruct energy of primary cosmic particle (with quasi-colorimetric method), estimate the depth of shower maximum (by the shape of charged particles lateral distribution and a pulse shape of Cherenkov light response in differential detector, t_{1/2}) and measure relative muon content at different core distances. In this work we consider a relation s_{mu} /s_{ch} between charged and muon components in showers and its fluctuations at fixed energies. The goal of this analysis is to make a comparison between experimental and computational data for different primaries and to obtain an estimation of cosmic rays mass composition in the ultra-high energy domain.

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The Depth of Maximum Shower Development and Its Fluctuations: Cosmic Ray Mass Composition at $E_0 \geq 10^{17}$ eV

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We present a new data on Cherenkov light observations obtained during 1994-2009 period, after a modernization of the Yakutsk EAS array. A complex analysis of x_{max} and its fluctuations \sigma(x_{max}) was performed in a wide energy range. With the new data, accord-
ing to QGSJet II model, an estimation was made of cosmic rays mass composition for E_0 \sim 10^{17} - 3 \times 10^{19} eV. The result points towards a mixed composition with a large portion of heavy nuclei at E_{0} \sim 10^{17} eV and the dominance of light nuclei at E_{0} \sim 1019 eV. The analysis of \sigma(x_max) energy dependence for the same energies qualitatively confirms this result. A shape of xmax distribution at fixed energy 1018 eV is analysed to make more precise conclusion on cosmic ray mass composition.

Emulsion chambers / 15

On capability of high coordinate-resolution techniques to study superhigh-energy hadron-nuclear interactions

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Capability of high coordinate-resolution techniques to study features of hadron-nuclear interactions at superhigh-energies are considered by the example of X-ray emulsion chamber (XREC) techniques. Main results accumulated by this way are discussed. Sensitivity of this approach to hadron-nuclear interaction features is analyzed. Predictions for future LHC experiments are formulated. Some proposals on future experiments are given.

Sensitivity of Monte Carlo models to data / 16

Relation of Interaction Characteristics at Ultra-High Energies to Extensive Air Shower Observables

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Only by measurement of extensive air showers it is possible to explore the nature of cosmic ray particles at the highest energies. Most properties can only be obtained from the interpretation of air shower data and are thus depending on predictions of hadronic interaction models at ultra-high energies. We discuss different scenarios of model extrapolations from accelerator data to air shower energies and investigate their impact on the corresponding air shower predictions. For this purpose we developed an ad hoc model, which is based on the modification of the output of standard hadronic interaction event generators within the air shower simulation process. This model allows us to study the impact of changing interaction features on the air shower development. In a systematic study we demonstrate the resulting changes of important air shower observables and discuss them also in terms of the predictions of the Heitler model of air shower cascades.

Recent relevant accelerator data and results / 17

Status and Prospects from the ATLAS Detector

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Since the startup of the LHC in December 2009, the ATLAS detector has been accumulating data from collisions at center of mass energies of 900 GeV and 7 TeV. Although the integrated luminosity is still low, it is increasing at an accelerated pace. The data have already made it possible to commission and calibrate the various subdetectors, understand their performance in detail and refine the trigger and software reconstruction algorithms. Initial measurements on charged particle multiplicities at \sqrt{s} = 900 GeV and 7 TeV as a function of pseudorapidity and transverse momentum have allowed comparisons to results from other experiments at the lower center of mass energy and to various Monte Carlo models of minimum bias events. Standard Model electroweak processes are also being used as benchmarks for validating the analysis and simulation tools. With the higher luminosity expected in the coming year, stringent tests of higher order QCD processes could be achieved. Various models of new physics could be probed and significant constraints obtained. The status of the detector will be summarized, and a brief review of physics results and expectations from early analyses will be given.

Anisotropy / 18

How dark matter cares about topological superstrings

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Non-trivial toplogical properties of string world sheets with three boundaries can give rise to superpotentials which preserve supersymmetry but violate R-symmetry by two units. This results in four point functions which permit s-wave annihilation of two neutralinos into gauge bosons. If the topological partition function is such as to allow saturation of the WMAP dark matter density for low string scales (M_s \sim 2 TeV), the annihilation into monochromatic gamma rays is predicted to lie about a factor of 2 below the current H.E.S.S. measurement of gamma ray flux from the galactic center. Thus, it may be detectable in the next round of gamma ray observations.

Poster Session I - Board 12 / 19

Multiparticle production in nucleus-nucleus interactions at 14.6 A GeV

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We present our observations on the various features from the 855 interactions of 14.6 A GeV 28Si in nuclear emulsion. Multiplicity distribution, mean multiplicities, multiplicity correlations of black, grey, shower and helium fragments are studied in this investigation. A comparative study of the results obtained from the interactions at 14.6 A GeV with other available data at the different energies per nucleon is also presented, which shows a good agreement with our experimental data. The study shows that production of grey particles has a linear dependence with shower particle multiplicity where as black particles exhibit a saturation effect, which describe the impact parameter dependence very well.

Emulsion chambers / 20

Analysis of one hadron rich event

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Analysis on a especial event with a main characteristics of Centauro type events, i.e. mean transverse momentum of hadrons in an order of 1 GeV/c will be presented. In spite of this event (Centauro V) doesn't show the aspect of pioneer event (Centauro I), that is the upper part of the detector has more particles than the lower part, the event Centauro V shows other common characteristics of Centauro I. Both two events has same value for the ratio height/radius of the spread area of particles, besides similar slope of the fractionally energy distribution of hadrons. As the discrimination and identification of hadronic showers is crucial, the analysis evolved construction of some kind of score tables, obtained with the use of parametric and non parametric statistics analysis, observing the photosensitive material (X-ray Films and Nuclear Emulsion Plates) and the comparison with computer simulated events behaviour inside the detector.

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LHCf measurements of very forward particles at LHC

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LHCf (Large Hadron Collider forward) is a dedicated experiment to measure the neutral particles emitted around zero degree of LHC interactions. Energy and Pt spectra of photons, pi-zero and neutral hadrons at such forward region are crucial to qualify the existing interaction models and to improve them for cosmic-ray physics. From the end of 2009, LHCf has successfully taken data at LHC collisions at sqrt(s)= 0.9 and 7TeV. In this presentation, the first results of LHCf mainly obtained since April 2010 will be presented together with the prediction of various interaction models.

Extensive air shower experiments / 22

Results from the GAMMA experiment on Mt. Aragats - improved data

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Status of the GAMMA experiment is presented. The all-particle energy spectrum of the primary cosmic rays at energies 1 – 300 PeV has been obtained on the basis of the GAMMA experimental improved data. The irregularities of the energy spectrum above the knee are discussed in comparison with other experiments. An upper limit of Galactic diffuse gamma ray flux measured with the GAMMA experiment at energy about 175 TeV is also discussed.

Poster Session I - Board 2 / 23

Studies of Emitted Particles in Nucleus-Nucleus Interactions at 4.5 A GeV/c

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Analysis has been done for the emitted particles in (12C, 16O, 22Ne, 28Si) + Emulsion interactions at (4.1-4.5) A GeV/c. The multiplicity of the emitted particles; as a function of the mass-number of the interacting projectiles nuclei; has been calculated. The multiplicity distribution and the average-values of the emitted particles (the experimental-values) are compared with that calculated values from Monte-Carlo simulation (the code developed at high-energy lab; Cairo university : "modified cascade evaporated model" (MCEM). Strong correlation between the number of the recoiled nucleons has been observed. An agreement has been shown between the experimental values and the theoretical calculated ones.

Sensitivity of Monte Carlo models to data / 24

Phenomenological approach to multiple particle production (1)

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We describe the rapidity density distribution and the transverse momentum (p_{t}) distribution in multiple particle production, assuming a simple mechanism. It is an assumed mechanism that the newly produced particles are emitted isotropically from several emitting centers which are distributed on the rapidity axis in CMS. The energy distribution of the emitted particles is an exponential type in the rest frame of respective emitting centers. The distribution of the emitting centers is uniform between -y_{0} and y_{0} (y_{0}=ln(sqrt{s}/M)-lna_{2}, a_{2} an adjustable parameter).
We can obtain the rapidity density distribution analytically, which can be transformed easily to the pseudo-rapidity density distribution and x-distribution.
The rapidity density distribution and the p_{T} distribution by the present formulation describes well those of the experiments at various energies by adjusting values of the parameters (five in total).
We show how well the experimental data at sqrt{s}=22.4, 546, and 1800 GeV
are described by the present formulation.

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Phenomenological approach to multiple particle production (2)

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In our previous presentation we showed how well the rapidity density distributions and the transverse momentum (p_{T}) distributions at sqrt{s}=22.4, 546 and 1800 GeV are described by our phenomenological formulation.
Based on the energy dependence of the values of the parameters, which are obtained by fitting the calculated distributions to those of the experiments, we examine how the present formulation describes the energy dependence of the p_{T} average, that of the multiplicity and the local p_{T} average along the rapidity y* in the forward region, obtained by UA7 Collaboration at sqrt{s}=630 GeV.
Extrapolating the energy dependence of the parameters into higher energies, we discuss the multiplicity, inelasticity and the pseudo-rapidity density distribution at sqrt(s)=1.4 x 10^{3} GeV (LHC energy) and 4.5 x 10^{5} GeV (10^{20} eV
in the laboratory energy), together with predictions by several models of multiple particle production.

Poster Session I - Board 22 / 26

Integrated circuit of coordinate detector for detection of charged particles

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New-type coordinate detector is considered which is based on special-purpose integrated circuit designed for detection of charged particles, local amplification and direct transmission of signal into computer. It is shown that such detectors make it possible to achieve a higher coordinate determination accuracy and processing speed as well as to bring down their cost as compared with modern detectors. It is possible to manufacture mosaic-structure large-sized detector panels with an active area-to-dead area ratio of not lower than ten. Detectors of this type could be applied in future space and balloon experiments.

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Hadronic- and electromagnetic-cores of air-showers observed by hybrid experiments at high mountains

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The Chacaltaya hybrid experiment together with emulsion chamber and EAS-array
can detect air-showers by the air-shower array, the accompanied atmospheric families
(a bundle of high energy electrons and gamma-rays) by emulsion chambers and hadrons
by burst detectors just under the emulsion chambers.
We study overall characteristics of the experimental data, gamma-families and hadron burst
accompanied by air-showers, by studying various correlations between the three
observable data, i.e, between families and air-showers, between bursts and air-showers,
and between families and bursts, comparing with those of CORSIKA simulations using interaction
models of QGSJET, SIBYLL and EPOS.
The analysis shows that changes of chemical composition alone can not describe the global
characteristics of the Chacaltaya hybrid data. That is, distributions of family energies are favorable to
heavy-dominant composition of primary cosmic-rays but lateral distributions of families are
favorable to proton-dominant composition.
The Chacaltaya hybrid data are also compared with those of Tien-Shan and Tibet hybrid experiments.
There are some discrepancies among the three experimental data though the details of experimental
procedure is different.
Discussions are given on the possible reason of the disagreement by comparing these experimental data with
simulations.

Poster Session I - Board 7 / 28

Modern status of high-mountain three-level ATHLET complex

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Three-level (3340, 1750 and 850 m a.s.l) ATHLET (Almaty Three Level Experimental Technique) complex is built up for investigations in fields of cosmic ray (CR) physics, astrophysics and gamma-ray astronomy of superhigh energies. The ATHLET's highest part has to include a) 1-km2-area ADRON-M facility with a "dense" location of detectors to detect electromagnetic, hadron, muon, neutron and radio EAS components with a high accuracy (~1 m) of determination of shower axes; b) specific shower array located at angle of ~45 degrees to detect showers in a wide range of zenith angles; c) GROZA complex for studying the nature of lightnings; d) "Muon beam" facility and classic seismic arrangements; e) a large instrumental complex to study low-energy components.
Physical investigation goals are as follows.
1) Astrophysics of cosmic rays (energetic spectrum and mass composition of primary cosmic radiation at E0 = 10^14 – 2x10^18 eV). 2) Gamma-ray astronomy (at E>50 TeV) (by selecting muonless, hadronless and neutronless showers). 3) Study of high-energy hadron interactions with atmosphere nuclei and selection of models which could describe EAS observable features in the best way. 4) Search for new phenomena. 5) Analysis of relations between neutron physics and EAS. 6) Mechanisms of lightning discharge and their connection with EAS and other CR-induced phenomena, 7) Solar radiation and "cosmic weather". 8) Seismology and EAS.
Modern status of detectors of the ATHLET complex is considered.

Poster Session I - Board 18 / 29

Threshold Cerenkov detector with Radial Segmentation (TCDRS)

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I present the prototype Threshold Cerenkov Detector with Radial Segmentation; as a part of the detector development and implementation research. The detector has three concentric cylinders, each with a different dielectric medium, and four scintillators that triggers cosmic particles with a time of fly of 5 ns. The radiator is designed to produce more photons as the particles travels into the TCDRS and fewer photons as it leaves. The correlation between the number of photons produced in the cylinders and the particle momentum allows particles separation of one sigma, for e, μ, π, κ, and p up to 5 GeV/c. Details of the TCDRS Monte Carlo, construction, data collection and data analysis are presented.

Muons / 30

Measurement of the charge ratio of atmospheric muons with the CMS detector

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A measurement is presented of the ratio of positive to negative muon fluxes from cosmic-ray interactions in the atmosphere, using data collected by the CMS detector at ground level and in the underground experimental cavern. Muons were detected in the momentum range from 3 GeV/c to 1 TeV/c. For muon momenta below 100 GeV/c the flux ratio is measured to be a constant 1.2766 ± 0.0032 (stat) ± 0.0032 (syst), the most precise measurement to date. At higher momenta an increase in the charge asymmetry is observed, in agreement with models of muon production in cosmic-ray showers and compatible with previous measurements by deep-underground experiments.

Poster Session I - Board 24 / 31

Spectral Analysis, and Hardness-ratios Correlations of SGR 1900+14 Bursts

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In the present study, we inspecte a refined sample of 117 bursts from SGR1900+14 observed with RXTE, PCA. We use 10 spectral-models, and the best fitting spectral-models has been found statistically to be the thermal bremsstrahlung and the power-law. Data are analyzed more by model-independent techniques. The global color-color diagrams are obtained with no distinguishable patterns as other objects like accretion disk neutron stars. Strong global correlations for burst timing and spectral properties with hardness-ratios has been found, and the most interesting ones are those between total hardness-ratios (soft/hard) and the bursts' total counts. That is, the hardness-ratio decreases; in the mean; with the burst-total-counts (more photons = softer spectrum.) Also this result is confirmed by the strong correlations obtained between bursts' total-counts and both hot-zone temperature (kT) and photon index (⊠). Classification of bursts depending on the burst-duration and the total photons-contained will be taken into consideration in our future studies of bursts.

Extensive air shower experiments / 32

The KASCADE-Grande experiment: recent results about the energy spectrum

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The study of the cosmic ray energy spectrum in the interval 10^16 eV - 10^18 eV results of particular importance for several reasons, one of them is the possible existence of a second knee, other one is the possible presence of a galactic-extragalactic transition in the cosmic ray flux and another one is the prediction from some astrophysical models of a knee in the energy spectrum of the heavy component of galactic cosmic rays. To address these questions precise measurements of the arrival direction, energy and composition of cosmic rays in this energy regime need to be performed. For this purpose the KASCADE-Grande air-shower detector was built at the place of the Karlsruhe Institute of Technology. The detector covers a 0.5 km^2 surface with different arrays of detectors which allows to measure simultaneously the charged and muon components of the air-shower events. With this information a lot can be learned about the composition and energy of the primary cosmic ray particles. In this talk, the KASCADE-Grande detector is described and first results of the experiment are shown, mainly about the all-particle cosmic ray energy spectrum in the energy region from 10^16 eV to 10^18 eV.

Recent relevant accelerator data and results / 33

First physics results at LHCb

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First pp collisions at sqrt(s) = 0.9 and 7 TeV have been recorded by the LHCb detector using a minimum bias trigger. These data are very valuable to commission the detector and trigger algorithms, but will also be used to perform a number of interesting minimum bias physics measurements, in the forward region covered by the LHCb detector (polar angles between 15 and 300 mrad), amongst which measurements of the prompt Kshort, Lambda, anti-Lambda, proton, anti-proton production cross sections, as well as of the Lambda transverse polarization. The motivations, ingredients and status of such measurements will be discussed, and preliminary results shown where available.

Poster Session I - Board 23 / 34

Study of primary cosmic rays at superhigh energies on the lunar surface and circumlunar orbit

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Mathematical model of experimental conditions on research for primary cosmic radiation (PCR) on the lunar surface and circumlunar orbit is considered. The fundamental possibility of detection of PCR particles is shown by the use of simultaneous detection of three components produced by cascades in the lunar regolith (secondary neutrons, gamma-ray and radio emission) measured by detectors placed on the lunar surface as well detectors located aboard a circumlunar-orbit scientific satellite. The "Neutronium" project combining these approaches is considered. Results of simulations are given

Poster Session I - Board 3 / 35

Pion Production Cross-section Measurements in p+C Collisions at the CERN SPS for Understanding Extensive Air Showers

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An important approach to studying high-energy cosmic rays is the investigation of the properties of extensive air showers; however, the lateral distribution of particles in simulations of such showers strongly depends on the applied model of low-energy hadronic interactions. It has been shown that many constraints to be applied to these models can be obtained by studying identified-particle spectra from accelerator collisions, in the energy range of the CERN Super Proton Synchrotron.

Here we present measurements of the pion production cross-section obtained by the NA61/SHINE experiment at the SPS, in proton-carbon collisions at the beam energy of 30 GeV from the years: 2007 and 2009. Further analyses of identified-particle yields in SHINE, in particular with a pion beam, are in preparation.

Anisotropy / 36

Cosmic magnetic fields, and implications for HE particle anisotropies

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A review will be given of what is known, and surmised about magnetic fields in space, from our Milky Way to the distant Universe well beyond the GZK horizon.
Various analysis methods are described. These include Faraday rotation (RM)
measures of extragalactic radio sources, Faraday probes of the cosmic background radiation, and the recent detection of faint diffuse synchrotron radiation in extragalactic space. I also review preliminary results of Faraday RM
probes of the intergalactic medium within clusters of galaxies, the Cen A environment, and some nearby filaments of cosmic large scale structure (LSS).
Faraday RM probes have also been applied to distant galaxies and quasars, out to z ⊠ 2 and beyond. I briefly discuss near-term possibilities for improving on some of the above probes.
I describe what is known about the local magnetic structure of the Milky Way in connection of UHECR propagation, and discuss what more progress needs to be made to better interpret the observed data on arrival directions, composition and primary particle energy.
The interpretation of UHECR energy/arrival direction/composition data can be clarified by our knowledge of the wider context of intergalactic magnetic fields. This clarification can be of a mutual nature. If the nucleus, jet, or lobes of nearby AGN galaxies within ~ 500 Mpc are the prime UHECR acceleration sites above ~ 1019 eV, it will be important to extend estimates of the magnetic field strength and turbulence scale to other nearby galaxies, galaxy halos, and to the intergalactic space between galaxies, galaxy groups and galaxy clusters. All of these measurements are important for modelling the propagation, deflection, and composition of observed UHECR events. Such studies will be of increasing importance for understanding the steadily growing number of observed UHECR air shower events.

Poster Session I - Board 4 / 37

High-energy atmospheric neutrinos

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High-energy neutrinos, arising from decays of mesons that were produced through the cosmic rays collisions with air nuclei, form unavoidable background noise in the astrophysical neutrino detection problem. The atmospheric neutrino flux above 1 PeV should be supposedly dominated by the contribution of charmed particle decays. These (prompt) neutrinos originated from decays of massive shortlived particles, $D^\pm$, D^0, $\overline{D}{}^0$, $D_s^\pm$, Λ^+_c, compose the most uncertain fraction of the high-energy atmospheric neutrino flux because of poor explored processes of the charm production. Besides, an ambiguity in high-energy behavior of pion and especially kaon production cross sections for nucleon-nucleus collisions may affect essentially the calculated neutrino flux. There is the energy range where above flux uncertainties superimpose.

A new calculation presented here reveals sizable differences, up to the factor of 1.8 above 1 TeV, in muon neutrino flux predictions obtained with usage of known hadronic models, SIBYLL 2.1 and QGSJET-II. This calculation of the atmospheric neutrino flux in the energy range 10 GeV-10 PeV is made within 1D approach to solve nuclear cascade equations in the atmosphere, which takes into account non-scaling behavior of the inclusive cross-sections for the particle production, the rise of total inelastic hadron-nucleus cross-sections and nonpower law of the primary cosmic ray spectrum. This approach was recently tested in the atmospheric muon flux calculations [Astropart. Phys. 30 (2008) 219]. The results of the neutrino flux calculations are compared with the Frejus, AMANDA-II and IceCube measurement data.

Sensitivity of Monte Carlo models to data / 39

Sensitivity of KASCADE-Grande data to hadronic interaction models

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KASCADE-Grande is a large detector array for the measurement of cosmic ray air showers in the primary energy range of 100 TeV to 1 EeV. Due to the multi-detector concept of the experimental set-up, various observables of the electromagnetic, the muonic and for lower primary energies also the hadronic particle component are measured for individual air showers. The experimental data are compared to predictions of CORSIKA simulations using high-energy hadronic interaction models (e.g. QGSJET or EPOS), as well as low-energy interaction models (e.g. FLUKA or GHEISHA). This contribution will summarize the results of such investigations. In particular, the validity of the new EPOS version 1.99 for EAS with energy around 100 PeV will be discussed.

Extensive air shower experiments / 40

Study of the longitudinal development of extensive air showers with the Muon Tracking Detector in KASCADE-Grande.

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The Muon Tracking Detector (MTD) in KASCADE-Grande experiment measures with high accuracy muon directions in EAS (Emu>800MeV). In addition, shower directions are determined by the surface detectors with high precision. These two conditions allow to study shower longitudinal development by means of quantities like muon production heights and muon pseudorapidities and lateral distributions of muon densities. Results of such investigations will be shown between 10^15 eV and 10^17 eV, for data and simulations based on CORSIKA with QGSJetII+Fluka2002.4 model combination and the new EPOS version 1.99. The muon pseudorapidity distributions will be studied in the predefined distance range to the shower core and compared to the simulations as well.The pseudorapidity distributions for muons which stem from above 15 km muon production height and which stem very likely from the first interactions are studied in more detail also in the context of geometric scaling in the near LHC energy range.

This work was supported in part by the German-Polish bilateral collaboration grant (PPP-DAAD/MNiSW) for the years 2009-2010

Balloon and Satellite Experiments / 41

Balloon-borne and Space-based Experiments with Non-magnetic Detectors

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Direct measurements of cosmic rays with satellite or balloon-borne detectors are used for understanding cosmic ray origin, acceleration and propagation, exploring the supernova acceleration limit, and searching for exotic sources such as dark matter. Their energy reach is currently limited to ~10^15 eV by the detector size and exposure time, but incident particles are identified element-by-element with excellent charge resolution. A challenge of balloon-borne and space-based experiments is that the detectors must be large enough to collect adequate statistics, yet stay within the weight limit for available space flight. Innovative approaches now promise high quality measurements over an energy range that was not previously possible. Recent measurement results will be reviewed and their implications will be discussed. The outlook for existing and future experiments with non-magnetic detectors will also be discussed.

Experiments above the Ankle / 42

The Telescope Array Low Energy Extension (TALE)

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The Telescope Array (TA) experiment is the largest cosmic ray detector in the northern hemisphere. It also operates the largest scintillation counter array in the world. Together with the three fluorescence detectors (FDs), it is optimized to study cosmic rays as independent detectors and in hybrid mode at energies above the ankle structure. The TA low energy extension will add two additional fluorescence detectors along with an infill array. The first of these will operate in stereoscopic view with an existing TA FD to study in detail the 0.3-30 EeV range around the ankle, with more than a factor of five improvement in aperture at 1 EeV over HiRes. The Tower fluorescence detector, using larger mirrors, will operate in hybrid mode with the infill surface array to measure the spectrum, composition, and anisotropy of cosmic rays down to 30 PeV, well below the "second knee". Together, TA and TALE will be able to measure simultaneously all three known spectral features in the ultra high energy (UHE) regime. TALE will also study the transition from galactic to extragalactic cosmic ray flux, with fluorescence Xmax capabilities for the first time.

Experiments above the Ankle / 43

The MIDAS Experiment: A New Technique for the Detection of Extensive Air Showers

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Recent measurements suggest free electrons created in ultra-high energy cosmic ray extensive air showers (EAS) can interact with neutral air molecules producing Bremsstrahlung radiation in the microwave regime. The microwave radiation produced is expected to scale with the number of free electrons in the shower, which itself is a function of the energy of the primary particle and atmospheric depth. Using these properties a calorimetric measurement of the EAS is possible. This technique is analogous to fluorescence detection with the added benefit of a nearly 100% duty cycle and practically no atmospheric attenuation. The Microwave Detection of Air Showers (MIDAS) prototype is currently being developed at the University of Chicago. MIDAS consists of a 53 feed receiver operating in the 3.6 to 4.2 GHz band. The camera is deployed on a 4.5 meter parabolic reflector and is instrumented with high speed power detectors and autonomous FPGA trigger electronics. We present the current status of the MIDAS instrument and an outlook for future development.

Muons / 44

Physics of high energy atmospheric muons

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In the first part of the talk the interesting new results of L3, MINOS and CMS collaborations are briefly discussed from theoretical point of view: an observational evidence of the rise in the muon charge ratio (L3 and MINOS data) at muon energies around 1 TeV and detailed studies of electromagnetic interactions of high energy muons (in a momentum range up to 1 TeV/c) in the medium of CMS detector. In the second part of the talk the recent calculations of atmospheric prompt lepton spectra are reviewed. The modern theoretical approaches to the problem of heavy quark production in high energy nucleon-nucleus interactions are briefly considered (color dipole formalism, saturation models). The recent new theoretical developments in the ancient problem of intrinsic charm are also discussed. The predictions for atmospheric muon spectrum in the region around 1 PeV (where the prompt muon contribution becomes to be dominant) are given.

Poster Session I / 45

Nucleon electromagnetic structure functions in extremely small x-region

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We present results of caslculations of transverse and longitudinal cross sections of photoabsorption on the nucleon target, in a broad region of very small Bjorken x values and not very large photon virtualities, using the two-component model developed by authors in their previous works. The model is based on the generalized vector dominance concept and color dipole approaches. The detailed comparison of the theoretical predictions with the HERA data is given.

Poster Session I - Board 17 / 46

The investigation of the hadronic interaction models using WILLI detector

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The WILLI detector, built in IFIN-HH Bucharest, in collaboration with KIT Karlsruhe, is a rotatable modular detector for measuring charge ratio for cosmic muons with energy < 1 GeV. It is under construction a mini-array for measuring the muon charge ratio in Extensive Air Showers. The EAS simulations have been performed with
CORSIKA code.
The values of the muon flux, calculated with semi-analytical formula, and simulated with CORSIKA code, based on DPMJET and QGSJET models for the hadronic interactions, are compared with the experimental data determined with WILLI detector. No significant differences between the two models and experimental data are observed.
The measurements of the muon charge ratio for different angles-of-incidence, (performed with WILLI detector) shows an asymmetry due to the influence of magnetic field on muons trajectory; the values are in agreement with the simulations based on DPMJET hadronic interaction model. The simulations of muon charge ratio in EAS performed with CORSIKA code based on three hadronic interaction models (QGSJET2, EPOS and SYBILL) show relative small difference between models for H and for the Fe showers; the effect is more ronounced at higher inclination of WILLI detector. The future measurements should indicate which model is suitable.

Poster Session I - Board 20 / 47

Fluctuation of TeV to EeV Energy Muons and the induced muon showers in Water

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By using the integral methods in the muon propagation through water, we calculate the range fluctuation of high and ultra high energy muons. Many authors divide all radiative processes into two part, namely, the continuous part and stochastic part in their Monte Carlo simulation in order to consider the fluctuation in the both range and energies of the muons, while we treat all radiative processes as exactly as possible, without the introduction of the continuous parts in all radiative processes. The validity of our Monte Carlo method is checked by the corresponding analytical method which is methodologically independent on the Monte Carlo procedure.
Accompanied electromagnetic showers are generated by the direct electron pair production, bremsstrahlung and photo-nuclear interaction. These showers are calculated by the exact Monte Carlo Method in one dimensional way.
We report survival probabilities, their differential energy distributions, range distributions and examples of individual muon behavior.

Poster Session I - Board 19 / 48

Ultra-High Energy Muon Neutrino Propagation through the Earth and Induced Muon Energy Distribution near the One Cubic Kilometer Detector

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We calculate high and ultra-high energy upward-going muon neutrino propagation through the Earth and the induced muon energy distribution near the one cubic kilometer detector using the Monte Carlo simulation, according to neutral current interaction. The primary neutrino energies on the surface of the Earth are 1PeV, 1EeV, and 1ZeV.
The mean free paths of ultra-high energy neutrino events generated by the deep inelastic scattering may be comparable with the diameter of the Earth or less than it. Therefore, the induced muon production distribution is influenced by the change of the densities interior to the Earth. Furthermore, in such situation, the contribution from the neutral current neutrino interaction to the induced muon production distribution cannot be neglected.
We report several examples of the deep inelastic scattered depth of muon neutrino in the Earth and the induced muon energy distribution near the detector.

Recent relevant accelerator data and results / 49

CASTOR LHC and cosmic rays

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CASTOR, a very forward ($5.2<\eta<6.6$) Čerenkov-light, tungsten/quartz calorimeter was installed and commissioned at CMS (LHC) in 2009. The calorimeter, with 16-fold φ-segmentation, 14-fold z-segmentation (224 channels) and 10λ(int), has been obtaining data since November 2009. The physics to be addressed with CASTOR include forward energy flow in pp, AA and pA, critical for the screening of EAS MC codes, as well as “exotic” topics, such as “Centauro” and “long penetrating” events, observed in VHE cosmic-ray data. The later constitute the reason for the novel design of the calorimeter. The first operational experience with CASTOR at CMS and the possibility of identifying “long penetrating” events will be presented and discussed.

Experiments above the Ankle / 51

AIRFLY: Precise measurement of the absolute yield of fluorescence photons in atmospheric gases

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We present preliminary results from the most recent data on the absolute yield of fluorescence photons in atmospheric gases by the AIRFLY collaboration. Currently, the uncertainty in the yield forms the dominant contribution to the systematic uncertainty in the Pierre Auger Observatory's energy spectrum, and are at the level of 10%. Data were taken in 2009 and 2010 at the test beam facility, M-Test, at Fermilab using protons, electrons and pions, in nitrogen, air, and in non fluorescing gases like argon, and helium. The instrument is operated in two main modes. In the first, fluorescence photons are observed, whereas in the second, both Cherenkov as well as fluorescence are observed. Comparisons of the ratio of these measurements, combined with the known Cherenkov spectrum allows for the absolute yield to be determined with reduced systematic uncertainties. In addition, the absolute yield is found by comparing the fluorescence yield to the observed photon yield of a NIST calibrated laser source directed into the apparatus. The consistency of these independent calibrations indicates that a systematic uncertainty of 5% or better is within reach.

Anisotropy / 52

Gamma ray signatures of ultrahigh energy cosmic ray sources in magnetized environments

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The quest for sources of ultrahigh energy cosmic rays has long been associated with the search of their secondary gamma ray signatures. While propagating, the former indeed produce very high energy photons through the interactions with particles of the intergalactic medium, or by synchrotron emission in the presence of substantial magnetic fields.

We examine the prospects for the detectability of gamma ray counterparts of ultrahigh energy cosmic ray sources in a general case, exploring a wide range of astrophysical parameters. We demonstrate the fair robustness of the gamma ray flux according to these parameters and that its normalization ultimately depends on the energy injected in the primary cosmic rays. We show that only very powerful and rare sources could be detectable with the current and upcoming instruments. We further demonstrate that if the extended emission of this signature is resolved (which should be the case with Fermi and CTA), such a detection should provide a distinctive proof of the propagation of ultrahigh energy cosmic rays. Finally, we also briefly discuss the detection of nearby sources, considering the radiogalaxy Cen A as a prototypical example.

Poster Session I - Board 10 / 53

The Measured Spectrum of the Telescope Array's Middle Drum Detector

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The Telescope Array's Middle Drum fluorescence detector was constructed using refurbished telescopes from the High Resolution Fly's Eye (HiRes) experiment. As such, there is a direct comparison between these two experiments' fluorescence energy spectra. A progress report will be presented based on over 2 years of collected data by the Middle Drum site of Telescope Array.

Poster Session I - Board 5 / 54

A Project of a Complex Setup at the Pamirs for Multi-Component Study of EAS and Parent PCRs in a Wide Energy Range Around the "Knee".

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A recommencement of CR researches with a unique X-Ray emulsion chamber (XREC) located at a high-altitude experimental site at the Pamirs (4360 m a.s.l.) in the framework of the Pamir-Chacaltaya International Scientific Research Center, recently established by the Governments of the Russian Federation and Tajikistan (2008), opens up a possibility for deep upgrading of the experimental setup and for deployment on its basis of a new complex one of 1 km^2 in area for EAS multi-component study including electron, muon, optic and hadron components, as well as a fine structure of EAS cores. The main purpose of the project is a detailed and per elemental study of the PCR spectrum in a wide range of primary energies E_0=30 x 10^6 TeV partially overlapping that of direct observations and containing the "knee" and other close intriguing irregularities of the spectrum. In addition, the designed setup will make it also possible to research a defuse γ-ray radiation with energy above 30 TeV in all northern hemisphere of the sky. The proposed project is based on a positive worldwide experience of creation of hybrid setups at mountain elevations which combines technique of EAS study by means of an array of spaced electronic detectors of charged particles with that of XRECs permitting to study a structure of EAS cores due to its high spatial resolution. A unique astronomical climate and high elevation of the Eastern Pamirs plateau provide excellent conditions for effective detecting of EAS Čerenkov light and particularly for detailed study of its space-angle characteristics, especially sensitive to the PCR composition. A spaced Čerenkov detector array of 245 x 245 m^2 in area complemented with 4 wide field-of-view (≥20°) imaging atmospheric Čerenkov telescopes (IACT) of 3-4 m in diameter with angular resolution 0.5-1.0° will be employed for determining of space-angle distributions of individual EAS. The atmosphere quality control will be performed with lidar technique. One more Čerenkov light telescope with ring-like system of mirrors (R=80 m) and cylindric mosaic of PMT in the center of the ring, which is specially designed for detection of Čerenkov radiation of the PCR nuclei, is under simulation now.

Recent relevant accelerator data and results / 57

First Results from the ALICE Experiment at the LHC

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The Large Hadron Collider (LHC) at CERN (Geneva, Switzerland) has successfully started operation in 2009. Collisions of protons at energies of 7 TeV are being provided to the experiments, the highest center-of-mass energy ever achieved in accelerators. The ALICE experiment at the LHC is designed for the investigation of heavy-ion collisions, but it is also well suited for studies of pp collisions.
In this talk, first results of the ALICE experiment from pp collisions at the LHC will be presented.

Poster Session I / 58

Cosmic ray composition around the knee.

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The Ne spectra for EAS and EAS with gamma-families are analyzed (Experiment "Hadron"-Tien-Shan).Presence thin structure (peaks) in EAS spectrum with gamma-families and necessity of simultaneous approximation of two spectra (EAS and EAS+γ) essentially the same mass composition limits possible models of nucleus individual spectra. The elementary variant of model when spectra of all five nuclear groups are similar is considered. Satisfactory approximation of both spectra Ne for EAS and EAS with gamma-families turns out in the assumption of magnetic rigidity of a break in spectra R=0.13 PV and presence of two peaks in the nuclear spectra at values of magnetic rigidity R=0.13 and 5.4 PV. This form of nuclear spectra permits to suggest two component CR composition. Presence of peaks in the nuclear spectra is explained by the contribution of radiation of single close source CR.

Balloon and Satellite Experiments / 59

The JEM-EUSO Mission to Explore the Extreme Universe

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The JEM-EUSO mission explores the origin of the extreme energy comic-rays (EECRs) above 10^20 eV and challenges to the limit of the basic physics, through the observations, of their arrival directions and energies. It is designed to observe more than 1,000 events of EECRs above 7x10^19 eV in its five-year operation with an exposure larger than 1 million km^2 /sr/year. The super-wide-field (60 degrees) telescope with a diameter of about 2.5m looks down the atmosphere of the night-side of the earth to detect near UV photons (330-400nm, both fluorescent and Cherenkov photons) emitted from the giant air-shower produced by an EECR. The arrival direction map with 1,000 events naturally tells us the origin of the EECRs and allows us to identify the EECR sources to known astronomical objects. The comparison among the energy spectra of the spatially resolved individual sources will clarify the acceleration/emission mechanism, and also finally confirm the Greisen-Zatse'pin-Kuzmin process for the validation of Lorentz invariance up to ~10^11. Neutral components (neutrinos and gamma rays) can also be detected as well, if their fluxes are high enough. The JEM-EUSO mission is planned to be launched by a H2B rocket about 2015 and transferred to ISS by H2 Transfer Vehicle (HTV). It will be attached to the external experiment platform of “KIBO” which completed July 2009 by STS-127 mission of the space shuttle.

Poster Session I - Board 21 / 61

On the Positron Fraction in Cosmic Rays and Models of Cosmic-Ray Propagation

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The positron fraction observed by PAMELA and other experiments up to ~100 GeV is analyzed in terms of models of cosmic-ray propagation. It is shown that generically we expect the positron fraction to reach ~0.6 at energies of several TeV, and its energy dependence bears an intimate but subtle connection with that of the boron to carbon ratio in cosmic rays. The observed positron fraction can be fit in a model that assumes a significant fraction of the boron below ~10 GeV is generated through spallation of cosmic-ray nuclei in a cocoon-like region surrounding the sources, and the positrons of energy higher than a few GeV are almost exclusively generated through cosmic-ray interactions in the general interstellar medium. Such a model is consistent with the bounds on cosmic-ray anisotropies and other observations.

Poster Session I - Board 14 / 63

TeV emission from NGC1275 viewed by SHALON 15 year observations

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Galaxy clusters have been consider as sources of TeV gamma-rays emitted by high-energy protons and electrons accelerated by large scale structure formation shocks, galactic winds, or active galactic nuclei. The Perseus cluster of galaxies is one of the best studied clusters due to its proximity and its brightness. Galaxy NGC 1275 is the central dominant galaxy of the Perseus Cluster of Galaxies and is of Seyfert galaxy class. NGC 1275 is known as powerful X-ray and radio source. Many studies explored correlations of X-ray radio optical and ultraviolet emission.
In 1996 year a new metagalactic source was detected by SHALON at TeV energies. This object was identified with Seyfert galaxy NGC 1275 (with redshift z=0.0179); its image is presented. The maxima of the TeV gamma -ray, X-ray and radio emission coincide with the active nucleus of NGC 1275. In contrast, the X-ray and TeV emission disappears almost completely in the vicinity of the radio lobes. The correlation TeV with X-ray emitting regions was found whereas the integral gamma -ray flux for this source is found to be $(0.78\pm0.13)\times10^{-12}cm^{-2}s^{-1}$ at energies of >0.8 TeV. The energy spectrum of NGC 1275 at 0.8 to 40 TeV can be approximated by the power law $F(> E_O) \propto E^k$, with $k=-2.25\pm0.10$. The Seyfert galaxy NGC 1275 has been also observed with the Tibet Array (about 5 TeV) and then with Veritas telescope at energies about 300 GeV at 2009. The recent detection by the Fermi LAT of high-energy gamma-rays from the radio galaxy NGC 1275 makes the observation of the very high energy (E > 100 GeV) part of its broadband spectrum particularly interesting. The overall spectral energy distribution of NGC 1275 from the low energies to the TeV energies is presented. The spectrum of NGC 1275 from SHALON 15 year observations is also shown. The search for gamma-rays from radio galaxies is important for the understanding of the dynamics and structure of active galactic nuclei.

Hadronic cross sections / 70

"Hadron cross sections: from cyclotrons to colliders to cosmic rays"

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Using the Froissart bound as a unifying theme, I will show that
the experimental data for hadronic crosssections, from nucleon-nucleon,
pion-proton, gamma-p and gamma*-p, are all consistent with a high energy
behavior saturating the Froissart bound, all rising with energy as log^2(s).
Using analyticity constraints that tie in very accurate low-energy total
cross section measurements for pp and pbar-p scattering, we make very
precise predictions for both LHC and cosmic ray energy cross sections.

Recent relevant accelerator data and results / 71

Particle production Experiments and their relevance to understanding Extensive Air showers

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Calculations of fluxes of atmospheric neutrinos and muons from extensive air showers suffer from our lack of knowledge of hadronic production processes. We are dependent of particle production models which suffer from systematics from both model dependent assumptions as well as the data used to tune them.
We will present recent published data from NA49, and NA61 experiments as well as present analysis from the MIPP experiment relevant to particle production and air showers. Prospects of getting higher quality data using the MIPP upgrade will be discussed.

Poster Session I - Board 15 / 72

Constrains of Extragalactic Background Light expected from observation of distant metagalactic sources 1739+522 (z=1.375) and 3c454.3 (z=0.859) (by SHALON Cherenkov telescopes).

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Extragalactic diffuse background radiation blocks the propagation of TeV γ-ray over large distances (z>0.1) by producing electron-positron pairs. As a result, primary spectrum of gamma-source is changed, depending on spectrum of background light. So, a hard spectra of Active Galactic Nuclei with high red shifts of 0.03 – 1.8 allow to determine an absorption by Extragalactic Background Light and thus spectrum of EBL. The redshifts of SHALON very high energy gamma-ray sources range from z=0.0183 to z=1.375. During the period 1992 – 2010, SHALON has been used for observations of the metagalactic sources NGC1275 (z=0.0183), SN2006gy (z=0.019), Mkn421 (z=0.031), Mkn501 (z=0.034), Mkn180 (z=0.046), OJ 287 (z=0.306), 3c454.3 (z=0.895), 1739+522 (z=1.375). Among them bright enough AGNs of BLLac type (Mkn421, Mkn 501) and FSRQ type (3c454.3, 1739+522) those spectra are resolved in the TeV energy band from 1 to ~20-30 TeV. Spectral energy distributions and images of distant Active Galactic Nuclei are presented. Spectral energy distribution of Extragalactic Background Light constrained from observations of Mkn421 (z=0.031), Mkn501 (z=0.034) 3c454.3 (z=0.859) and 1739+522(z=1.375) together with models and measurements are presented. Observations of distant metagalactic sources have shown that the Universe is more transparent to very high-energy gamma-rays than previously believed.

Experiments above the Ankle / 81

HiRes

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Atmospheric Effects of High Energy Cosmic Rays

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It has been suggested that events such as supernovae, gamma ray bursts (GRBs) and motion of the Sun perpendicular to the galactic plane may expose the Earth to an enhanced flux of high energy Cosmic Rays (HECRs). The electromagnetic component of the resulting air showers leads to an increase in ionization and dissociation in the atmosphere which results in a series of chemical reactions. These reactions occurring in the stratosphere deplete the ozone, resulting in an increase in the solar UVB flux at the ground level. This could be harmful to a variety of organisms such as phytoplanktons which form the base of the food chain. Enhanced ionization could also result in an increase in the low altitude cloud cover, thereby increasing the albedo and cooling the planet. Magnitude of these effects depend on the flux of cosmic rays hitting the atmosphere. Using CORSIKA and NASA GSFC 2D photochemical code, we perform detailed computer simulations of 10 GeV − 1 PeV range primaries interacting with the Earth's atmosphere and construct a model to quantify these effects for an arbitrary astrophysical source. Data up to PeV primaries is freely available and is being extended for EeV primaries.

Poster Session I - Board 16 / 102

On the origins of the highest energy cosmic rays

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Active galactic nuclei (AGNs) appear to be the most plausible source of ultra-high energy cosmic rays (UHECRs), yet there is currently no conclusive evidence for this hypothesis. Correlation between the arrival directions of some UHECRs and the positions of nearby AGNs has been reported for a sample of 27 UHECRs detected by the Pierre Auger Observatory (PAO 2007), although analyses of larger samples find a weaker signal (PAO 2010). Here we present a fully Bayesian analysis of the original PAO data, which makes use of more of the available information, and find, with 3 sigma confidence, that a subset of observed UHECRs originate from known AGNs listed in the Veron-Cetty and Veron (2006) AGN catalogue. We will extend our analysis to more homogeneous AGN catalogues such as the Swift BAT sample.

Recent relevant accelerator data and results / 103

Recent accelerator data and results from the Tevatron

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We present relevant results from CDF and D0, including diffractive and elastic scattering, and other inclusive measurements.

Hadronic cross sections / 104

The proton-air inelastic cross-section measurement at sqrt(s) ~ 2 TeV from EAS-TOP experiment.

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The proton-air inelastic cross section measurement at sqrt(s) ~2 TeV from the EAS-TOP Extensive Air Shower experiment is reported. The technique exploits cosmic ray proton primaries, in the energy region $E_0 = 1.5-2.5 x 10^15 eV, studying the absorption length of their cascades when detected at maximum development. Primary energies are selected through the EAS muon number, and proton originated cascades at maximum development by means of the shower size. The shower and detector fluctuations are obtained by means of simulations performed using the CORSIKA code and the QGSJET II and SIBYLL interaction models. The statistical and systematic uncertainties, as well as the relationships with the pp total cross section measurements are discussed.

Poster Session I - Board 8 / 105

Extensive air shower simulation for the Telescope Array surface detector

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The history of ultra-high energy cosmic ray observation is now approaching 50 years. However, until quite recently, the full simulation of an extensive air shower was computationally impossible due to the vast quantity of daughter particles involved. However, with the advent of modern cluster computing, simulations that once would have taken years to complete can be done in a matter of hours or even minutes. Full shower simulations produced by a parallelization scheme employing the Karlsruhe Extensive Air Shower Simulation Code (CORSIKA) will be presented in conjunction with a ``dethinning'' technique that attempts to recover information lost by the CORSIKA statistical thinning algorithm. Detailed comparisons between simulated and real event sets will then be presented

Poster Session I - Board 11 / 106

Impact of X-Ray Emulsion Chamber Response on Gamma-Family Observable Characteristics

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Analysis of various data accumulated in X-ray emulsion chamber experiments, especially, data on gamma–hadron families with unusual characteristics (Centauros, aligned events etc.), requires a comprehensive computer code to simulate propagation of electromagnetic and various-type hadron particles through a sandwich-like medium of emulsion chambers as well as measuring procedures employed for emulsion chamber data processing. Such a new code, ECSim 2.1, has been recently elaborated on the basis of GEANT 3.21 package. As compared to the latter, the ECSim 2.1 takes into account the LPM effect for gamma-rays and electrons, uses new cross sections of muon interactions of different types allowing also for the LPM effect in pair generation, incorporates QGSJET or MC0/FANSY models for simulation of high-energy hadron interactions and accounts for production and interactions of charm particles. Besides, measuring and data treatment procedures employed in the Pamir experiment are simulated properly. An impact of X-Ray emulsion chamber response on gamma-family observable characteristics is discussed.

Sensitivity of Monte Carlo models to data / 107

Sibyll with Charm

Dr. AHN, Eun-Joo [1]; ENGEL, Ralph [2]; GAISSER, Thomas [3]; LIPARI, Paolo [4]; STANEV, Todor [3]

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The cosmic ray interaction event generator Sibyll is widely used in extensive air shower simulations for cosmic ray and neutrino experiments. Charm particle production has been added to the Monte Carlo with a phenomenological, non-perturbative model that properly accounts for charm production in the forward direction. As prompt decays of charm can become a significant background for neutrino detection, proper simulation of charm particles is very important. We compare charm meson and baryon production to accelerator data.

Emulsion chambers / 108

Proton Fraction in the PCR Flux at the Energy Range E_0=1-100 PeV According to the Pamir Experiment Data

Dr. BORISOV, Alexander [1]; Dr. DENISOVA, Valentina [1]; Mr. KOGAN1, Mikhail [1]; Dr. KANEVSKAYA, Evgeniya [1]; Dr. MUKHAMEDSHIN, Rauf [2]; Dr. PUCHKOV, Vitaliy [1]

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A detailed study of X-Ray emulsion chamber response with ECSim 2.1 computer package adopted from GEANT 3.21 code and suited for imitation of measuring procedures, employed in the Pamir experiment makes it possible to determine more accurately the proton fraction in the primary cosmic ray (PCR) flux at energies around the “knee” E_0=1-100 PeV. In particular, it is shown that the proton fraction in the PCR slowly decreases from 20% at E_0 ~ 1 PeV to 15% at E_0 ~ 10 PeV.

Muons / 109

Measurement of cosmic muons - L3+C results

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The L3+C is a unique tool in detecting cosmic muons and measuring their momenta in the range of 15-3000 GeV/c. About 1.2 x 10^{10} cosmic muon events have been collected during its running period in 1999-2000. With these high quality data many results on cosmic rays and gamma rays have been obtained, for example, the measurement of the atmospheric muon spectrum and the muon charge ratio, the search for TeV anti-protons by the moon shadowing, the coincidence of muons with the solar flares, the search for transient flaring point sources by detecting the muon burst, the analysis of muon bundles and comparison to simulations, and so on. In this talk, above results as well as a few of remarks on the future muon experiment will be summarized and presented.

Poster Session I - Board 9 / 110

Bistatic Radar: A New Method for Detecting Cosmic Rays

Mr. MYERS, Isaac [1]; Prof. BELZ, John [1]; Mr. LUNDQUIST, Jon Paul [1]; Prof. THOMSON, Gordon [1]; Dr. TAKAI, Helio [2]; Dr. SOKOLSKY, Pierre [1]; Mr. VAN KLAVEREN, Brian [1]

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Progress in the study of high energy cosmic ray physics is limited by low flux. In order to collect substantial statistics above 10^{19}~eV, the two largest ground arrays currently in operation cover 800~$\mbox{km}^2$ (Telescope Array, Utah) and 3000~$\mbox{km}^2$ (Auger Observatory, Argentina). The logistics and cost of an order-of-magnitude increase in ground array aperture is prohibitive. In the literature, radar detection experiments have been proposed but substantial results have not been reported. Here, we describe our plans to build and test a bistatic radar facility overlapping the Telescope Array (TA) in Delta, Utah. We have obtained an FCC license to broadcast a constant wave 54.1~MHz signal over the large TA ground array, with radar echoes to be received at our detection facility on the far side of the array. Systems monitoring and data logging systems are currently being developed. Our immediate goal is to detect cosmic rays in coincidence with TA by reflecting radar signals from the air shower ion core. Through subsequent detector advances we will seek to determine air shower geometry and energy.

Experiments above the Ankle / 111

Analysis Techniques for the TA SD Detector

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Abstract: The Telescope Array experiment is the largest cosmic ray experiment in the northern hemisphere. It consists of a surface detector (SD) of 507 scintillation counters and three fluorescence stations overlooking the SD. We develop new techniques for estimating cosmic ray energies and calculating the aperture for TA SD which utilize an accurate CORSIKA Monte Carlo (MC) simulation of natural cosmic rays with appropriate energy spectrum, angular distribution, and composition so that the generated MC has all characteristics of the real data. The simulation is verified by detailed comparisons of MC distributions and fit results with those of the real data. Results of applying these analysis techniques to the actual TA SD data will be shown.

Introductory presentations / 113

Cosmic rays: current status

Prof. GAISSER, Thomas [1]

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Important new results in four areas of particle astrophysics are on the agenda of this conference: atmospheric leptons; direct measurements of composition and spectrum to 100 TeV; air shower measurements from the knee to the ankle; and the upper end of the cosmic-ray spectrum. Each of these topics has a long history, with the techniques and the basic questions being established early on. What is relative contribution of pions, kaons and charm to leptons in the atmosphere? Do all species of primary cosmic rays have the same source spectra and propagation history? Where is the transition from galactic cosmic rays to a higher energy population of particles from extra-galactic sources? Is there a suppression of the highest energy particles due to energy loss during propagation through the cosmic background radiation? In this introductory talk I will comment on the current status of each topic in its historical context.

Colloquium / 114

The Composition of Cosmic Rays: Questions, Surprises, and Recent Answers

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Even though cosmic rays have been observed for almost a century, they remain enigmatic messengers from distant regions in space, and many questions about their origin and acceleration are still open. Details of the composition and of the energy spectra of the individual components are required to find answers, but are increasingly difficult to obtain with increasing particle energies. We will review the present knowledge, emphasizing the energy region below the “knee” where direct observations are possible, and discuss current measurements, their implications, and future prospects. We also will discuss some of the challenges that are associated with recently reported data on rare components such as electrons, positrons, and anti-protons.

Welcome / 115

Symposium Opening Remarks

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Welcome from the Fermilab Directorate

Balloon and Satellite Experiments / 117

Status of AMS

Prof. TING, Samuel C.C. [1]; Prof. KOUNINE, Andrei [1]

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The Alpha Magnetic Spectrometer (AMS) is a major particle physics experiment on the International Space Station (ISS). AMS is a general purpose particle physics spectrometer using the technologies commonly employed at CERN and Fermilab and upgraded for space applications. The properties of the AMS detector are that it will provide a coordinate resolution of 10 microns, a timing resolution of 150 ps and a velocity resolution of 1 part in 1000. It will simultaneously measure e+, e-, p, p-bar and nuclei up to the TeV region. For its 20 year stay on the ISS it will provide a sensitive search for the origins of Dark Matter, the existence of antimatter, the existence of strangelets and so forth.

AMS is a DOE sponsored international collaboration involving 600 scientists from 16 countries. It is schedule to be transported by the Space Shuttle to ISS in November 2010.

Experiments above the Ankle / 118

Measurement of UHECRs by the Telescope Array (TA) experiment

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The Telescope Array (TA) experiment, located in the west desert of Utah, USA, observes ultra-high energy cosmic rays (UHECRs) with energies above 10^18.5 eV. TA employs a surface detector (SD) array and 3 batteries of fluorescence detectors (FDs) to measure extensive air showers. The direction and the energy of incoming cosmic rays are measured by both detectors, and the results can be cross checked. The primary composition can be determined by the longitudinal shower development measured by the FD and the muon content inferred at the SD. A full detector is running since May, 2008. The design and the performance of TA, its operational status and the first year results will be presented in the meeting.

Recent relevant accelerator data and results / 119

Status and prospects from TOTEM

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Totem is exploring the forward region at
pseudorapidity larger than 3.1; its main goal is the measurement of the
total and elastic cross-section at 14 TeV and the study of diffractive
physics in the forward region.

The experiment is now built and almost
completely commissioned; data taking started in December 2009.

TOTEM aims at measuring the total cross section beyond 1 TeV/c with the
unprecedented precision of 1 % by using the luminosity independent method,
based on the simultaneous detection of elastic scattering at low
momentum transfer and of the inelastic interactions. To achieve this,
protons scattered at very small angles in elastic or quasi-elastic
reactions will be measured in telescopes of silicon detectors enclosed
in Roman Pots, placed on both sides of the intersection regions;
inelastically produced secondaries will be measured by a forward
inelastic detector covering the region 3 < eta <7 with full azimutal
acceptance.

The TOTEM physics program includes the measurement of forward
charged multiplicity distributions at the TEV scale, important for the
understanding of the cosmic ray events. TOTEM will take data under all
LHC beam conditions including standard high luminosity runs to maximize
its physics goals.

Poster Session I - Board 13 / 120

Two source emission behavior of projectile fragments alpha in 84Kr interactions at around 1 GeV per nucleon

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The emission of projectile fragments alpha has been studied in 84Kr interactions with nuclei of the nuclear emulsion detector composition at relativistic energy below 2 GeV per nucleon. The angular distribution of projectile fragments alpha in terms of transverse momentum could not be explained by a straight and clean-cut collision geometry hypothesis of Participant – Spectator (PS) Model. Therefore, it is assumed that projectile fragments alpha were produced from two separate sources that belong to the projectile spectator region differing drastically in their temperatures. It has been clearly observed that the emission of projectile fragments alpha are from two different sources. The contribution of projectile fragments alpha from contact layer or hot source is a few percent of the total emission of projectile fragments alphas. Most of the projectile fragments alphas are emitted from the cold source.

Introductory presentations / 121

Accelerator Data

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I shall present selected examples of accelerator data, mainly from hadron colliders, that are relevant for understanding cosmic ray showers. I focus on the forward region, x(Feynman) > 0.05, where high energy data are scarce, since the emphasis in collider physics became high-pT phenomena. I discuss whether that situation can be improved.

Muons / 122

MINOS Cosmic Muon Results

Prof. SCHREINER, Philip [1]

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When high energy cosmic rays interact in the stratosphere, mesons are produced in the primary hadronic interactions. The MINOS experiment detects cosmic ray produced muons using two magnetized detectors at underground depths of 220 and 2080 mwe. The muon charge ratio and the variation of muon intensity with atmospheric temperature are used to obtain information on meson production by the primary cosmic rays in the atmosphere. The ratios of positive to negative pions, positive to negative kaons, and charged kaons to pions are obtained.

Anisotropy / 123

Tev Cosmic Ray Anisotropy in Milagro

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Using the Milagro data from 2000 to 2007 containing more than 95 billion events (the largest such data set in existence), we performed a harmonic analysis of the large-scale cosmic-ray anisotropy. We observe an anisotropy with a magnitude around 0.1% for cosmic rays with a median energy of 6 TeV. The dominant feature is a deficit region of depth 0.25% in the direction of the Galactic North Pole centered at 189 degrees right ascension. In addition, we made an unexpected discovery of a localized cosmic-ray anisotropy, showing up as two high significance regions of excess cosmic rays. Recently, both Tibet AS Gamma and ARGO have confirmed similar excesses co-located with the Milagro regions. These features appear on an angular scale of ~10 degrees and have a harder than the background cosmic ray distribution, and the spectrum appears to cut off around 10 TeV. In this talk these results will be discussed as well as possible explanations for this surprising result.

Recent relevant accelerator data and results / 124

Recent Results from CMS

Dr. GRESELE, Ambra [1]

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The status of CMS concerning the 2009 run and the first data recorded at 7 TeV in 2010 will be reported. After a summary of the LHC and detector performance, including some example of interesting events, the talk will focus to the first results obtained. In particular, emphasis will be given to low-pT QCD physics including charged hadron spectra, the measurement of Bose-Einstein correlations (BEC) and of underlying event properties.

Experiments above the Ankle / 125

Results from the Pierre Auger Observatory

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The Pierre Auger Observatory in the southern site of Mendoza, Argentina is the largest cosmic ray detector ever built. Since its completion in 2008, the Observatory is steadily taking data with 3000 km**2 of active detection area, accumulating an unprecedented statistics of high quality events. Results are presented on the energy spectrum of cosmic rays from 10**18 eV to the highest energy, on the anisotropy of the arrival direction of the highest energy cosmic rays, and on the nature and composition of cosmic rays.

Recent relevant accelerator data and results / 126

Perspectives on Nuclear Physics Input into High-Energy Cosmic Ray Interactions

Prof. BALANTEKIN, Baha [1]

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Recent ultra high-energy cosmic ray data hints an increase of heavier nuclei in the composition of the cosmic ray flux, accentuating the importance of more precise nuclear physics input. In this talk recent results from relativistic heavy ion and other nuclear experiments will be summarized and the possible impact of these results on understanding cosmic ray interactions will be discussed.

Introductory presentations / 127

Relating accelerator data and models

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The study of high energy cosmic rays requires a good understanding of the properties of hadronic interactions.
Information on the strong interactions can be obtained in experimental studies at accelerators,
however the modeling of cosmic rays showers requires an extrapolation of the observations made at accelators with some guidance from theoretical ideas.
This talk will review some of the key problems for these extrapolations
and the resulting systematic uncertainties.
The possibility to obtain information on the hadronic nteractions from
cosmic ray observations will also be considered.

Extensive air shower experiments / 128

The present status of the GRAPES-3 experiment

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The GRAPES-3 experiment is a high density array of 400 plastic scintillator detectors and a large (560 sq.m.) area muon detector located at Ooty at an altitude of 2200 m above sea level. The primary objective of this experiment is to study the high energy processes occurring in the universe through a systematic study of composition of primary cosmic rays below and above the `knee', compact sources of multi-TeV gamma rays, diffuse flux of gamma rays and the solar accelerator through the impact of coronal mass ejections, solar flares etc. To achieve these objectives extensive in-house development of necessary instrumentation including plastic scintillator and high-speed signal processing electronics has been carried out. The development of high performance TDC and silicon photo-multiplier have the potential to complete change the nature of scientific problems that can now be addressed. During the talk some of these aspects would be highlighted.

Experiments above the Ankle / 129

Final Results from the High Resolution Fly's Eye (HiRes) Experiment

Prof. SOKOLSKY, Pierre [1]

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Final results from the HiRes experiment on the spectrum, composition and anisotropy of ultra-high energy cosmic rays will be presented. Stereo and monocular data analysis will be described. The HiRes experiment has observed the Greisen-Zatsepin-Kuzmin cutoff. This analysis and evidence for a light composition of cosmic rays to the highest energies will be presented. Recent results on anisotropy relative to large scale structure of the universe will also be discussed.

Balloon and Satellite Experiments / 130

Balloon-borne and Space-based Particle Measurements with Magnetic Spectrometers

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Using high-performance superconducting or permanent magnets coupled with precision detector systems, magnetic-rigidity spectrometers have the unique ability to completely identify incident particles by charge, charge-sign, mass, and energy. Magnetic spectrometers are central to measurements of cosmic antiparticles and the spectra of light isotopes and elements. Positron and antiproton spectra measured by magnetic spectrometers are important in constraining dark-matter models as well as models for the origin, acceleration, and transport of cosmic rays in the Galaxy and Heliosphere. Searches for heavier antinuclei probe symmetry-breaking processes in the early Universe. Measurements of light-isotope spectra to relativistic velocities constrain models for cosmic-ray transport and storage in the Galaxy. Instrumental techniques used in modern magnetic-rigidity spectrometers and results from recent experiments will be reviewed. Prospects for future magnetic spectrometer instruments will be discussed.

Extensive air shower experiments / 131

Cosmic Ray Physics with IceTop and IceCube

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IceTop air shower array, as the surface component of the IceCube Neutrino Observatory at the South Pole, is now 92% complete and taking data with 73 stations. The detector will study the mass composition of primary cosmic rays from the knee up to about 1 EeV. In this talk the performance of IceTop, and the preliminary results in the energy range of 1 PeV to 80 PeV will be reported.

Joint Experimental-Theoretical Physics Seminar / 132

Xmax from Auger and its interpretation

Dr. AHN, Eun-Joo [1]; Dr. ENGEL, Ralph [2]

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Xmax, the depth of maximum number of charged particles in the atmosphere during the longitudinal development of an air shower, is a valuable parameter to understand the nature of cosmic rays. The behaviour of Xmax is closely related to the composition of the primary particle. Hadronic interaction models, which are tuned with accelerator data, are required to understand the composition. Hence past, present, and future accelerator data are crucial in shaping our understanding of cosmic rays. The southern Pierre Auger Observatory has observed nearly 4000 high quality events above 1 EeV with the fluorescence detector and at least one surface detector in coincidence. We describe the data collection criteria and the Xmax mean and fluctuations, and outline how cosmic rays can aid understanding of hadronic interactions beyond collider energy.

Sensitivity of Monte Carlo models to data / 133

Modeling Hadronic Multiparticle Production at Very High Energy

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After introducing the general structure of event generators used for simulating cosmic ray interactions we describe the underlying philosophy of the Monte Carlo models EPOS, QGSJET, SIBYLL, and DPMJET. Some of the important assumptions of the models are reviewed in detail and the prediction obtained with the models are discussed. The reliability of the predictions is one of the key questions for which the new LHC data give valuable input. The relation of model predictions to general air shower features will be presented and uncertainties estimated. Finally, the most important open questions will be listed and ways of addressing them outlined.